

# FATIGUE SCIENCE

## Achieving ROI with Readiband

Discover how Readiband Solution can drive significant safety and financial benefits in fatigue risk management for mining, construction, oil & gas, and transportation firms

Reduce  
fatigue risk by

**24%**

Reduce  
accidents by

**18%**

Achieve ROI  
of at least

**12x**



April 2018

# An introduction: how objective fatigue data changes everything

## Introduction

Quantifying the cost of fatigue to one's business can be a **daunting proposition**. Historically, industrial and transportation firms have recognized that fatigue has a very large, real cost to their operations, but they've lacked the means to put a number on it. Without this grounding, it's been even harder to project a financial *benefit* from technologies that help achieve a *reduction in fatigue*.

**Objective data changes everything.** With our wrist-worn Readiband, firms can now gain an objective, quantified view into the fatigue exposure of their workforces. Combining the world's leading biomathematical fatigue algorithm, the SAFTE™ Alertness Model, with validated sleep data from the wrist-worn Readiband, it's finally possible to put a number on fatigue.

These fatigue data are **the key to linking** your workforce's fatigue exposure with the ultimate cost that fatigue is having on your business.

In our methodology that follows, we reveal how pairing hourly fatigue data with KPIs from your business (such as accident exposure) can, in conjunction with industry benchmarks, provide a reliable means of projecting the financial impact to your business.

But projecting your current cost exposure is only the beginning. Launched in 2017, our *"Readiband Solution"* combines our Readiband with a mobile companion app. With this app, Readiband **is no longer merely a fatigue measurement tool** – it's a full toolkit that helps workers achieve *reductions* in their own fatigue.

To that end, we'll walk you through how Readiband Solution helps firms **reduce their fatigue risk by 24%** in the first few months

of use, and we'll show you these results translate into a projected **12x or greater ROI**.

Of course, ultimately what matters when evaluating a fatigue risk management solution isn't merely what has worked for others – although that's a worthwhile consideration. In the end, what matters is the projected effect Readiband Solution can have on *your* organization.

Therefore, consider the following methodology merely a sample, or framework. During a trial deployment, our expert team of analysts will offer to work closely with your stakeholders to build you a business case **customized to the parameters of your organization**.

This business case typically accounts for unique factors like your firm's own fatigue exposure, the nature of the work being done, your shift schedule and any rostering considerations, and your firm's own independent measures of accident and incident exposure. We look forward to collaborating closely with your team in this effort.

## Methodology Overview

Our methodology begins with an introduction to the science of our proprietary fatigue model, where we'll discuss what **SAFTE Alertness Scores** mean, and we'll share evidence relating those scores to real-world accident risk. Then, we'll introduce the concept of a **Fatigue Risk Profile**, a key notion in aggregating the data collected from a sample of your workers. From there, we'll use internal estimates and industry benchmarks to relate this profile to actual accident costs and productivity impacts. Finally, we'll project a change in your organization's Fatigue Risk Profile based on past results from ongoing use of the Readiband. This will allow us to arrive at our ultimate conclusion: **ROI**.

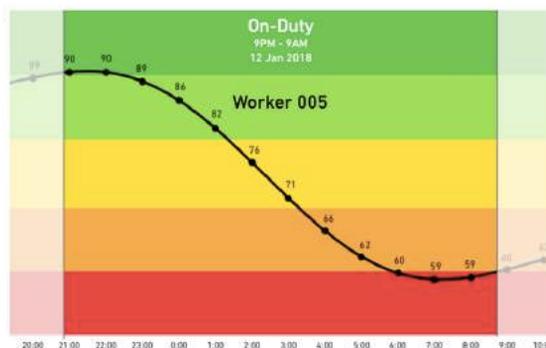
# The SAFTE™ Model and the science of quantifying fatigue

## What is the SAFTE™ Model?

The SAFTE™ Biomathematical Fatigue Model is the core algorithm we use to quantify worker fatigue. The SAFTE Model was developed by the **US Army Research Lab over the past 25 years, with over \$37 Million** invested in R&D and validation costs. The US Army developed the model to optimize the human performance of soldiers, who often face many of the same demands and conditions as industrial workers. In order to bring the model to a wider market, Fatigue Science acquired its exclusive rights, and we built on top of it a wearable platform called *Readiband Solution* to enable industrial workers and athletes to benefit from this military-grade fatigue solution. (It's also relied on by top sports teams, including recent Superbowl™ and World Series™ winners).

The SAFTE Model projects one's cognitive fatigue that will occur on account of a number sleep-related factors, including one's historical sleep patterns, the timing of one's sleep, and one's expected circadian rhythm (based on seasonal factors like sunrise times). When given new sleep data, the model assesses the **cumulative impact of all these factors** in order to come up with an **hour-by-hour** projection of one's fatigue for the day ahead. These hourly projections are called **SAFTE Alertness Scores**.

*Below: Hourly Alertness Scores for a given worker, on a givendate, on a 12-hour Night Shift*



As shown to the left, SAFTE Alertness Scores can be related to objective physiological impacts, such as **Reaction Time, Lapse Index, and Cognitive Effectiveness**. "Lapse Index" is a measure of one's propensity for a momentary *lapse* – which is related to concepts such as "microsleeps" and "nodding off". Cognitive Effectiveness (indicated by the score itself), is based on research using an objective set of decision-making tests.

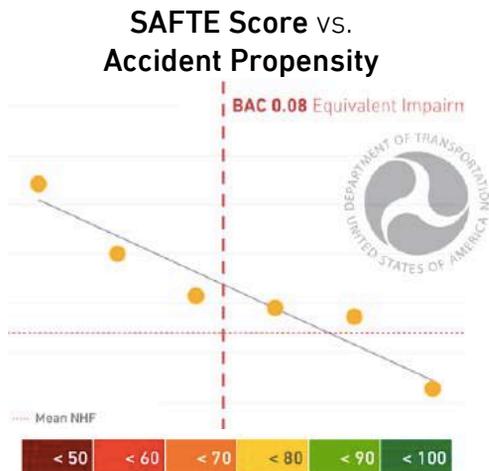
For instance, at a score of 70, one is predicted to be 70% as mentally effective, with 43% slower reaction time and a 5.2x greater chance of a lapse—similar to the effects of a 0.08 Blood Alcohol Concentration. Unlike alcohol use however, fatigue is sometimes unavoidable, such as on night shifts where even healthy sleepers may briefly dip below 70 on account of fighting against one's natural circadian rhythm.

*SAFTE Alertness Scores, with associated projected physiological impacts*

# Relating SAFTE™ Scores to the real-world safety outcomes

## Independent Studies

The real world impacts of operating with a low SAFTE Alertness Score have been studied extensively by leading agencies such as by the US Department of Transportation and the US Federal Aviation Administration. For instance, the US DoT found a direct correlation between one's predicted SAFTE Alertness Score and his or her **accident propensity**.

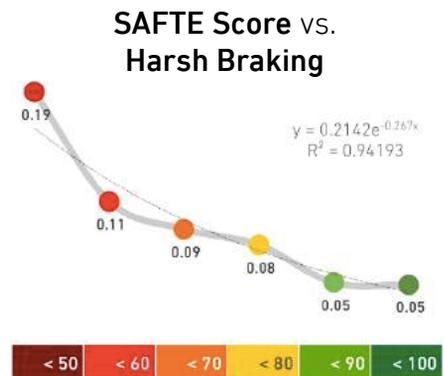


Similarly, this study revealed that accidents are not only much more likely with a low SAFTE Score, they are often much costlier (up to **5x the cost** of a typical non-fatigued accident).



## Client Telematics Data

A study of our own clients' telematics data further confirms these tendencies, revealing that drivers operating with a score below 50 are **8.5x more likely** to excessively speed.



Similarly, drivers operating with a score below 50 were found to carry a **4x greater likelihood** to engage in excessive speeding.



In mid-2018, we will be conducting even more studies into the relationship of SAFTE Scores and safety outcomes, using telematics and safety event data with authorization from some of our clients. We expect to release more findings later this year. *(Note: If you'd like to see correlations specific to your organization, we're happy to perform analyze your data too.)*

# Aggregating hourly fatigue data into a Fatigue Risk Profile

## The “Fatigue Risk Profile”

Obtaining an understanding of your operation’s current fatigue exposure is a key step in projecting ROI. Typically, when clients begin their journey in adopting the Readiband, they start with a **30-day baseline fatigue assessment** (prior to rolling out the Readiband for broader ongoing use.)

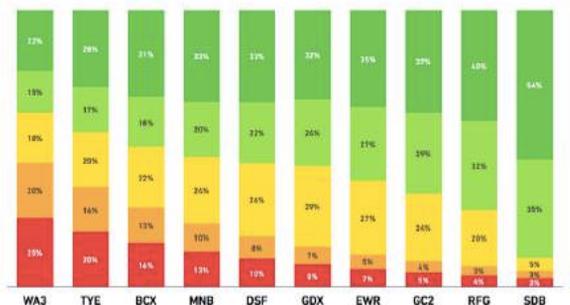
In this baseline assessment, it’s typical to have a **sample of 10 – 15% of workers** at a given site wear the Readiband for data capture purposes. Here, we anonymously capture hourly fatigue data for each of the workers during their on-duty hours.

Over ~30 days (or sometimes, one full rotation), we use these hourly data to construct an anonymous “Fatigue Risk Profile” for each worker in the sample. This profile reveals what **percentage of time on-duty** each individual spends in each of five key SAFTE Score ranges, as shown in the example of a heavily fatigued worker below.

With enough workers in a representative sample, the individual Fatigue Risk Profiles of can then be combined to collectively construct an **Aggregate Fatigue Risk Profile** for your organization (or for a site within it).

Your Aggregate Fatigue Risk Profile can then be used as a **benchmark** for your overall exposure to fatigue risk exposure – and it will become a key metric for **tracking reductions** to this exposure over time.

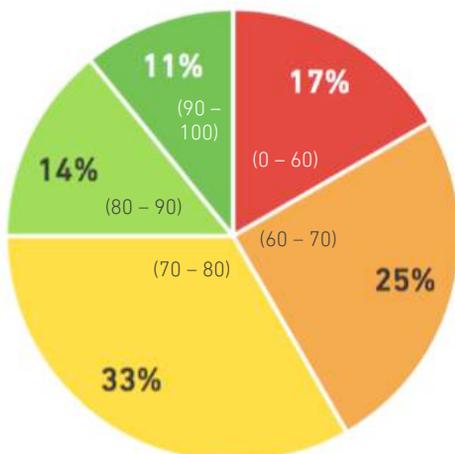
## All Individual Fatigue Risk Profiles



### Individual Fatigue Risk Profile

Worker ABC, Jan 2018

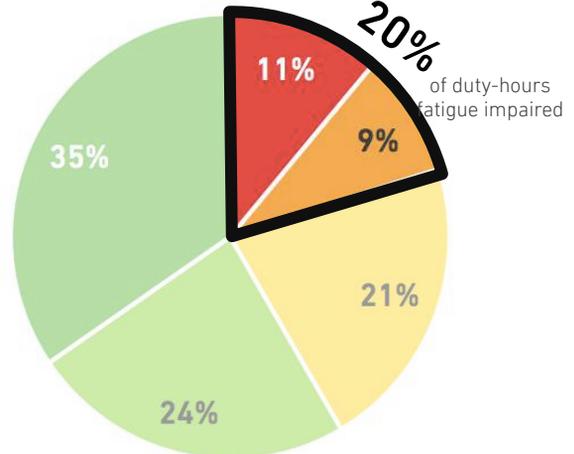
(% of duty hours, by SAFTE Score)



### Aggregate Fatigue Risk Profile

Site A, Jan 2018

(% of duty hours, by SAFTE Score)



# Relating your Fatigue Risk Profile to your accident exposure & costs

The next step in determining ROI is to come up with an assessment of **how many accidents are attributable to fatigue** in your organization. Without an objective record of fatigue's presence in each historical accident, this will always require an estimation exercise.

In this effort, there are three key data points that help us make an informed assessment:

- Your organization's total accident exposure
- Your organization's industry
- Your organization's own fatigue risk profile

## Your Accident Exposure

Fatigue causes many types of accidents, from Lost-Time Incidents (LTI's) to less significant ones. We'll typically focus just on LTI's (although others are costly as well), and we'll use either company-specific data or general data from your industry to inform this estimate.

## Your Industry

Once we come up with a total estimate of LTI's for your organization, the question becomes, **"What portion of these are fatigue-related?"**

Because fatigue affects different fields of work differently, a good place to start is by using benchmarks for your industry. For instance, a 2011 study by Caterpillar Global Mining found that 65% of surface haul truck accidents were attributable to fatigue. To be conservative, it may be reasonable to assume a figure closer to 50% of such accidents for general mining. Less research exists in Oil & Gas, but given similar tasks, perhaps 50% is also reasonable here.

In transportation, 1990s-era studies suggested that 15-20% of accidents were fatigue-related. However, more recent, US DOT and ATSB reports suggest an amount is closer to 35-40%. In the field of construction, less research exists,

but 35% may be a safe assumption given fatigue's presence in other industries.

## Your Fatigue Risk Profile

While an industry average is a good place to start, it's possible that your organization is more or less exposed to fatigue than a typical peer. Fortunately, your Fatigue Risk Profile can help calibrate this estimation: comparing it to industry benchmarks, we can increase or decrease this estimate proportionally.

With this calibration in place, let's work through an example to estimate the total number of Fatigue-Related LTI's (FR-LTI's) for a typical Oil & Gas firm. For instance, such a firm may have 5.34 total LTI's per 1,000 workers annually. If 50% of these LTI's are fatigue-related, that's 2.67 FR-LTI's annually.

Now let's say this firm's Fatigue Risk Profile is typical for its industry and it projects ~16% of all its duty hours to be fatigue-impaired. We know 1,000 workers work ~2M hours annually. Therefore, these workers work ~316K hours annually while fatigue-impaired. And because all fatigue-related accidents, by definition, come from hours that are fatigue-impaired, we can infer in this example that **2.67 LTI's occur for each 316,000 fatigue-impaired duty hours.**

*Below: an example of this extrapolation*

SAFTE Alertness Range	% of Duty Hours	# of Duty Hours (per 2M)	Implied # of F.R. Accidents
90 - 100	15.3%	306,000	
80 - 90	39.9%	798,000	
70 - 80	29.0%	580,000	
65 - 70	7.1%	142,000	0.76
60 - 65	5.2%	104,000	0.55
55 - 60	1.3%	26,000	0.34
50 - 55	0.7%	14,000	0.25
0 - 50	1.5%	30,000	0.77
<b>Total</b>	<b>100.0%</b>	<b>2,000,000</b>	<b>2.67</b>

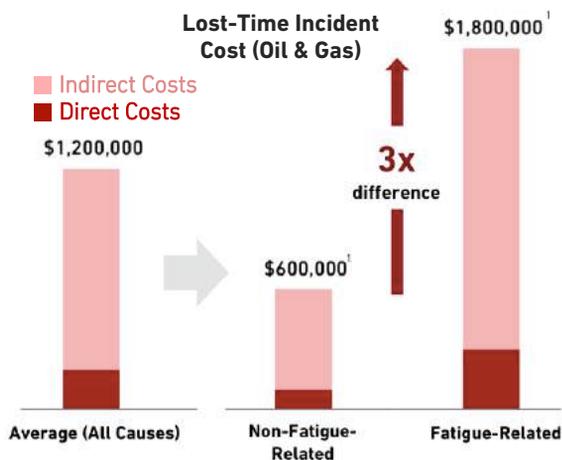
*Total < 70    15.8%    316,000*

## Fully-Loaded Accident Costs

Once we've estimated the *frequency per fatigue-impaired hour* of Fatigue-Related LTI's in your operation, we can apply estimates of the average cost per incident in order to come up with the total cost exposure.

Fatigue-related incidents are generally found to be **far more severe** than those not related to fatigue, with the US DoT finding up to a 5x cost differential as discussed previously. (To be conservative, we'll use only a 3x estimate.)

In Oil & Gas, for example, the average *direct* cost of a LTI is estimated at US\$200,000. With a 50/50 ratio of FR to Non-FR accidents and a 3x cost differential, this suggests a \$300,000 average *direct* costs for FR-LTI's.



**Direct costs** can include things like workers compensation payouts, medical costs, and equipment damage.

However, the **indirect costs** of LTI's can be many times larger, with studies suggesting a 5:1 ratio of indirect to direct costs<sup>1</sup>. Indirect costs can include damages to buildings, sites, and resources, work stoppage, re-training, HR replacement, crisis management time, and legal fees.

Combining all of the above, we find the average "**fully-loaded cost**" of an FR-LTI in the oil & gas industry to be **\$1.8M**.

Using this math, we estimate that those 2.67 FR-LTI's incurred by 1,000 workers annually would cost **approximately \$4.8M**.

Therefore, we can consider **\$4.8M the total addressable size** of the fatigue-related accident problem caused by 1,000 Oil & Gas workers annually in this example. (*Note: this is the total addressable size, not the projected savings, which we'll later determine as a fraction of this number.*)

## Productivity Impacts

Aside from accidents, there is believed to be a massive impact to productivity when fatigue is present in any field of work. While this is intuitive—workers are less productive when tired—it's also difficult to quantify. We need to be cautious because even a single percentage point change to productivity can have a massive impact on projected cash flows and ROI.

The best estimates available suggest that worker fatigue costs workforces about 4% of total productivity<sup>2</sup>. For our Oil & Gas example, annual output is estimated at be \$727,000 per worker, suggesting a productivity loss of \$29M annually per 1,000 workers.

Because this figure is so large, and is also admittedly the least robust part of our methodology, we'll recommend taking a fairly drastic haircut here. Let's assume perhaps only a quarter of this amount is addressable. Therefore, we assume a **max of \$7.3M** in productivity gains are possible if all fatigue were eliminated. (*Note: this, again, is the "total addressable size"; not projected gains.*)

## Total Opportunity Size

Combining the above figures, we estimate a **total addressable opportunity of \$12.1M** per 1,000 workers annually – if all fatigue were to be completely eliminated.

<sup>1</sup>Based on data from a 2012 report by Hubler et al. which described the weighted-average direct cost for Lost-Time Injuries (LTI) to be \$200,000 across all (both FR and non-FR) accidents. This report also projected a 5:1 ratio between indirect costs and direct costs, resulting in an average total "all-cause" accident cost of \$1,200,000 for LTI.

<sup>2</sup>Loss of 4% in productivity due to fatigue is estimated based on "The Cost of Poor Sleep: Workplace Productivity Loss and Associated Costs", Journal of Occupational and Environmental Medicine, Jan 2010

# Improving your organization's Fatigue Risk Profile

## Better Sleep, Less Fatigue

Having made an estimate of the total addressable opportunity from fatigue reduction, the next question naturally becomes, what portion of this opportunity can Readiband **actually realize**?

This, naturally, depends on how much our Readiband Solution can *reduce* worker fatigue: **the more fatigue is reduced, the more our projected gains.**



Fundamentally, Readiband Solution helps workers achieve better sleep habits, and in turn, obtain better sleep and ultimately less fatigue. It achieves this by not only revealing to workers their own fatigue **data** (levels and trends), but also by providing them with **education** around possible sleep habit changes – and concrete **tools** to put all this guidance into action.

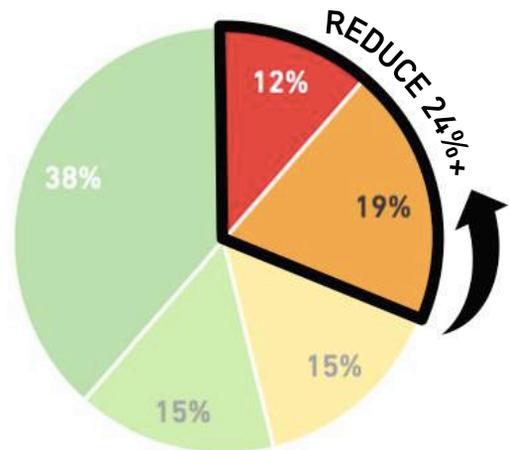


Readiband Solution

Guidance includes practical tactics in the areas of Sleep Opportunity Planning, Sleep Hygiene, and Sleep Environment. As workers use the Readiband app daily to enact this guidance, they strive for “Alertness Goals” – higher SAFTE Alertness Scores that are personally achievable for them.

## How Effective is Readiband?

When our Readiband Solution launched in early 2017, its functionality was more “bare bones” than described above. We provided users their raw data but did not offer much in the way of education or tools for action. Still, data is a powerful motivator! Using this version of the app, Readiband users achieved an average of **26 minutes** more sleep per night, with over 80% of them raising their SAFTE Alertness Scores. Consequently, our clients saw a **24% average reduction** in on-duty fatigue risk (for example, from 30% of duty hours fatigue-impaired down to 23%).



In May 2018, we're launching an even more powerful Readiband app, where users will be engaged with a full suite of **data, education,** and concrete **tools** that will further support sustainable sleep habit changes. We expect to see even greater results with this version!

# Adding it all up to project your return on investment

## Projected Accident Reduction

By projecting a change in your Fatigue Risk Profile, we can project **how many fewer hours** would be worked while in a state of fatigue-impairment. In our current example, we projected exposure to 316K fatigue-impaired hours per 2M total hours. These 316K hours carried an associated figure of 2.67 FR-LTI's.

If we assume, based on past results, that the Readiband Solution can achieve a 24% average reduction in fatigue-impaired hours, this would suggest a reduction from 316K fatigue-impaired hours per 2M, down to only 240K (in essence, moving 76,000 hours “**up and out of the red**”, typically with some of the greatest gains coming from the most severely impaired levels of fatigue).

Holding constant the assumed accident frequency *per fatigue-impaired hour*, we can then project a new implied number of FR-LTI's in such an scenario.

SAFTE Alertness Range	% of Duty Hours	# of Duty Hours (per 2M)	Implied # of F.R. Accidents
90 - 100	15.9%	318,000	
80 - 90	41.0%	820,000	
70 - 80	31.1%	622,000	
65 - 70	6.5%	130,000	0.70
60 - 65	3.5%	70,000	0.37
55 - 60	1.3%	26,000	0.34
50 - 55	0.4%	8,000	0.14
0 - 50	0.3%	6,000	0.15
<b>Total</b>	<b>100.0%</b>	<b>2,000,000</b>	<b>1.70</b>
<i>Total &lt; 70</i>	<i>12.0%</i>	<i>240,000</i>	

In this example, as illustrated above, we now project 1.70 FR-LTI's per 1,000 workers, down from 2.67 FR-LTI's previously projected (i.e., a **projected reduction of 0.97 FR-LTI's per 1,000 workers** annually, or 18% of the original 5.34 LTI's of any type).

## Projected Cost Reduction

With a projected 0.97 fewer FR-LTI's per 1,000 workers, we then simply multiply this figure by \$1.80M, the estimated fully-loaded cost per FR-LTI that we utilised previously.

Thus, we project a fully-loaded **accident cost savings of \$1.75M annually per 1,000 workers.**

*(Note: With greater improvements to one's Fatigue Risk Profile, this figure could be much larger, up to the maximum addressable size we calculated previously, of \$4.8M. Therefore, organizations are often keen to continue tracking improvements to their Fatigue Risk Profile to determine their realized benefits on an ongoing basis).*

## Projected Productivity Gain

Similarly, in our example, we had previously projected potential productivity gains of up to \$7.3M per 1,000 workers annually—if all fatigue impairment were to be eliminated.

With a 24% reduction in fatigue impairment, we can thus extrapolate **\$1.74M in annual gains to productivity per 1,000 workers.**

## Total Improvement & ROI

In total, having used conservative assumptions throughout this analysis, we project a **grand total of \$3.49M in annual financial benefit** by equipping 1,000 workers with Readiband Solution in our example.

Readiband technology and deployment costs vary, but equipping 1,000 workers is generally achievable for under \$300,000 annually. Thus, here we arrive at our conclusion, projecting a total **ROI of 11.6x** for our sample customer.

# Let's estimate your organization's own safety and financial impact

Every organization is unique. Your own organization's own fatigue risk, incident exposure, and productivity dynamics can vary according to a multitude of factors, such as scheduling, the nature of the work being done, and the underlying sleep health of your workers.

As part of a **30-Day Trial** of Readiband, we'll provide you with a customized, comprehensive **Fatigue Risk Assessment** that will estimate your own organization's fatigue risk exposure – and its opportunity for its reduction.

In the process, we'll also build you a custom business case, aligning closely with key stakeholders in your organization and leveraging parameters specific to your own KPIs. With this effort, you'll gain a clear, quantifiable picture of how Readiband can make a material improvement to both the safety and financial outcomes of your organization.

To learn more, speak to a member of our Sales Team for a free consultation.

---

## PROUD WINNER OF INDUSTRY AWARDS



**WINNER**  
2017 VINCI  
INNOVATION AWARDS



**FINALIST**  
2017 BRITISH CONSTRUCTION  
INDUSTRY AWARDS



**WINNER**  
2017 NEW CIVIL ENGINEER  
TECHFEST AWARDS



**HIGH  
COMMENDATION**  
2017 INTERNATIONAL RAIL  
INDUSTRY AWARDS

**FATIGUE  
SCIENCE**

Contact a member of our sales team via:

Web: [www.fatiguescience.com](http://www.fatiguescience.com)  
Email: [sales@fatiguescience.com](mailto:sales@fatiguescience.com)  
Phone: +1 (604) 408-0085  
(In the UK: +44 (020) 3884 1061)

1588-409 Granville St  
Vancouver, BC V6C 1T2